Using Neural Networks and Logistic Regression to Predict Septic Shock in ICU Patients.

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Introduction/Background

Septic shock is rapidly emerging as one of the leading causes of morbidity and mortality in hospitals worldwide. Better prediction systems and models are necessary to alert clinicians when early goal-oriented therapy can be given to ICU patients with characteristics evident of future septic shock. Artificial neural networks bring about a new realm in regards to information analysis of electronic health records. This study led to the formation of SEPalert, a novel septic shock alert system obtained by training a model estimating likelihood of patients developing septic shock criteria by sixteen non-zero primary parameters. The SEPalert system was compared against TREWscore(0.83) and MEWS score(0.73) which are previously published models which both attempt to predict the likelihood of septic shock in patients currently admitted to the ICU.

Problem Statement

Using a model of neural networks with both linear and non-linear regression analysis, can SEPalert be a better system for predicting septic shock in ICU patients than both TrewScore and MEWS.

Methodology

Using sixteen non-zero parameters frequently found in ICU patients we formed a model to develop SEPalert. We evaluated these features using both linear and non-linear regression models on 16,235 patients found in the MIMIC 2 ICU database. Each individual feature was assigned a weight and optimized to give the ideal system to predict septic shock. The MIMIC-II database is a publically available database that is part of the Multiparameter Intelligent Monitoring in Intensive Care project funded by the National Institute of Biomedical Imaging and Bioengineering at the Laboratory of Computational Physiology at MIT.

Results

SEPalert is a novel septic shock prediction model with an area under the receiver operating characteristic(ROC) curve (AUC) of 0.91 which outcompetes both TREWscore(0.82) and the MEWS score(0.73) (Figure 1). As part of the data analysis, we looked at each of the sixteen features individually to look at changes between septic shock vs non septic shock patients. Looking at the Chart_duration features, septic shock patients had 1188 chart events on average compared to 345 for non-septic patients (Figure 2). Days spent in the ICU for septic patients was greater as well with an average length of stay of 13.5 days vs non-septic patients at 4.43 days (Figure 3). These features can further help clinicians understand when in the future patients may be at risk for developing septic shock.

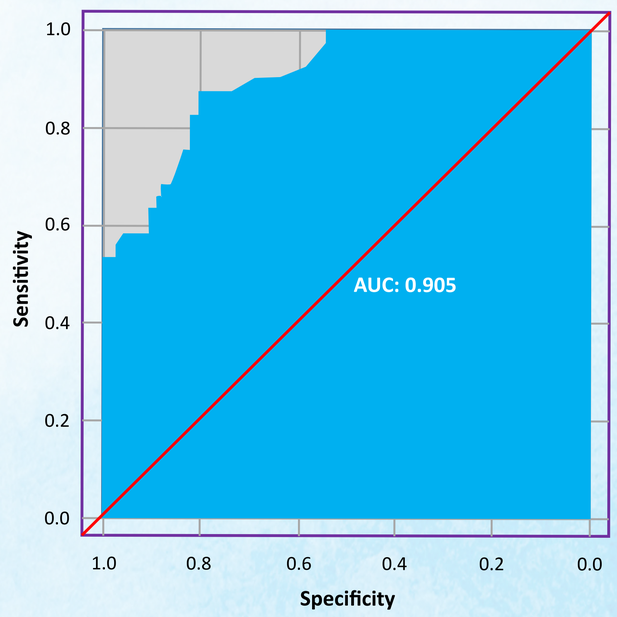

Figure 1. AUC using linear and non-linear regression model to evaluate patient data. Demonstrates an AUC of 0.905 which outcompetes previous models such as TrewScore and MEWS.

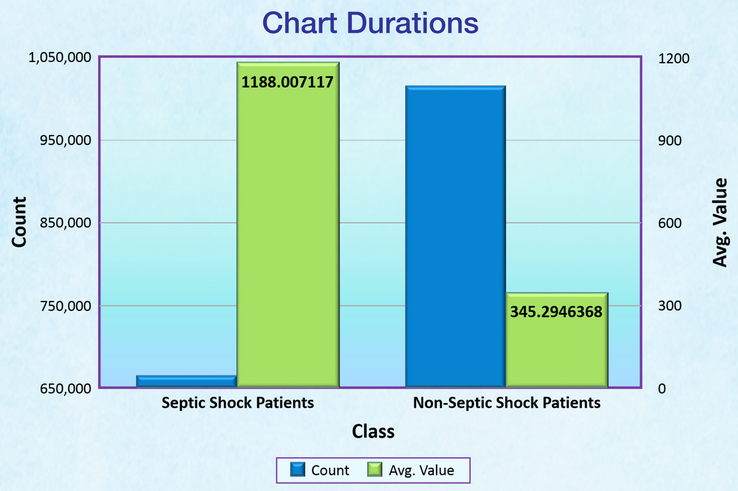

Figure 2. On average patients with septic shock have a longer chart duration(the length of time on chart events categorized by the unit team during the patient ICU stay) (1188.0) vs. patients without septic-shock(345.2)

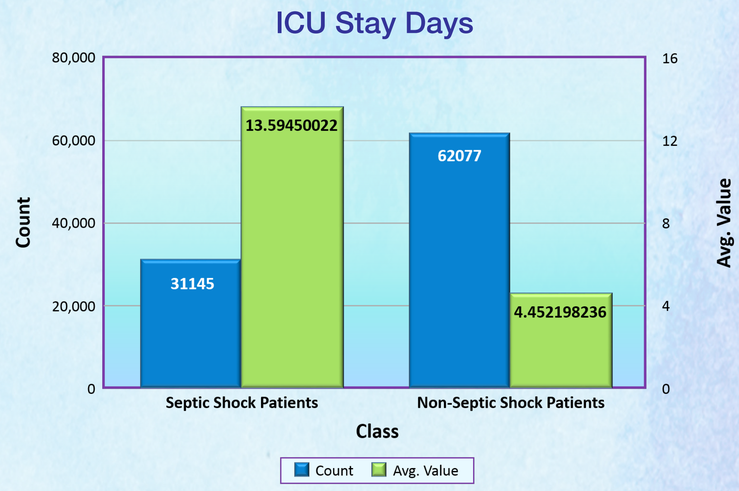

Figure 3. On average patients with septic shock have a longer ICU Stay period(13.59) vs. patients without septic-shock(4.45)

Conclusions and Future Implications

The MIMIC-II clinical database was used to develop SEPalert, a novel real-time warning score using both linear and non-linear regression and thus a supervised regression model to predict septic shock in ICU patients. Achieving better prediction models for septic shock is critical given the better outcomes associated with early intervention prior to shock onset. Future goals of the project are to use ICU data from hospitals such as Lehigh Valley Health Network to train our model and ultimately provide clinicians with an easier model to identify which patients have the highest likelihood for septic shock.